Introduction

This Supplement provides guidance for properly preparing explosives for shipment and transfer, and outlines requirements for transporting explosives on site and on public highways. For assistance in the preparation or transportation of a specific explosive, contact the Site 300 Explosives Distribution Section (EDS) or the Hazards Control Explosives Safety Office.

When used in this Supplement, the words "shipment" or "shipping" indicate the movement of explosives on public highways. This movement is monitored by the California Highway Patrol. As prescribed by DOE Orders, all packaging, labeling, applicable shipping documents, and transportation requirements must be in accordance with Department of Transportation (DOT) regulations contained in 49CFR 100–179. Appendix A of this Supplement is a procedural guide that conforms with DOT regulations pertaining to the classification of explosives for shipment.

The words "transfer" or "transferring" when used in this Supplement refer to the intrasite movement of explosives, which is regulated as described below. The movement of explosives between Livermore and Site 300 or between LLNL and Sandia National Laboratories, Livermore is treated as a shipment.

Responsibilities

The Site 300 EDS of the Supply and Distribution Department is responsible for packaging, labeling, and preparing the shipping documents for explosives shipments leaving Site 300. The Materials Management Division (MMD) is responsible for packaging, labeling, and preparing the shipping documents for explosives shipments leaving the Livermore site.

For transfers, the person in control of the explosive is responsible for proper packaging, labeling, and completing the ID tag for controlled materials (LL-3076). This person is also responsible for notifying MMD at the Livermore site or EDS at Site 300 to arrange material movement and for addressing the explosives to an authorized facility and to an approved Explosives Handler.

Receipt of Explosives Shipments

Non-LLNL Shipments

Explosives shipments from off-site locations are normally delivered to Site 300 EDS, Building 818, for processing. In special cases EDS personnel may determine that the destination or weight of the explosives shipment is such that processing should be handled at another facility.

A small cement cubicle (M-345-1), located within the fenced area northwest of Building 345 (Livermore), has been designated as the off-hours receiving area for DOT Class C explosives arriving at the Livermore site. Whenever deliveries are made to this area, MMD shall be notified to either receive the material for on-site delivery or to make arrangements for its transfer to Site 300.

Intersite Shipments

The two major areas at the Livermore site for receiving and dispatching intersite shipments are Building 229 (Chemistry Area), and Building 345 ("B" Division Test Facilities). At Site 300, the proper area is the EDS Facility at Building 818, unless otherwise designated.

Explosives Transfer Points

Once an explosives material has been processed at the shipping/receiving area, it may then be transferred between approved explosives-handling areas on the same site provided that (1) the

material is authorized by a Safety Procedure, (2) the weight limit for that facility is not exceeded, and (3) the material is processed for transfer as described in this Supplement.

Preparation for Shipment

DOT Classification

All explosives or explosive devices to be shipped on public highways must receive the approval described in Appendix A of this Supplement and possess a DOT shipping classification. The three DOT shipping classifications for explosives are:

Class A—Detonating or otherwise of maximum hazard.
Class B—Flammable hazard.
Class C—Minimum hazard.

A "new" explosive can be shipped on public highways if it is not a Forbidden or initiating explosive, and if it has been approved and classified as described in Appendix A.

Packaging

Explosives to be shipped off site must be transported to EDS, Building 818, for packaging. An exception to this policy is made by EDS if the classification or weight of the material may make it more feasible to package and pick up for shipment at another facility. All explosives destined for shipment shall be packaged in containers as specified in 49CFR. Where a specified container cannot be used, a DOT exemption may be granted for a special packaging scheme. An exemption request is submitted by MMD to DOT (through DOE) with the information specified in 49CFR, Parts 103 and 107. After approval, DOT will issue a DOT-E number to identify the approved exemption. The MMD maintains a list of packaging configurations for which LLNL has a DOT exemption.

All empty shipping containers being returned to EDS must be inspected by the sender to ensure that the containers are indeed empty and must be tagged with an Empty Tag and an LLNL Delivery Tag (LL-1158-1).

Labeling

Primary containers used for shipping explosives must be tagged with an Explosives Identification Label (LL-4299) giving the name, weight, storage review date (if applicable), LLNL explosive classification, and storage group.

For shipments on public roads, DOT shipping containers must have the appropriate DOT labels affixed. Unlabeled or incorrectly labeled containers shall not be transported or shipped.

Documentation

The ID tag for controlled materials (LL-3076) is required when shipping explosives between Livermore and Site 300. The tag must be properly completed in legible print. Personnel intending to make a shipment of an approved explosive to a non-LLNL addressee must submit a Request for Shipment/Material Pass (LL-216-1) to MMD for approval. When explosives are to be shipped on public highways (including shipments between Livermore and Site 300) a shipping document is also required. The Straight Bill of Lading is the primary document used and must be properly completed, including the correct DOT shipping name and DOT Hazard Class. MMD (for shipments leaving the Livermore site) or EDS (for shipments leaving Site 300) is responsible for completing the shipping document. For waste explosives, the Hazardous Waste Management (HWM) Group is responsible for completing the Hazardous Waste Shipping Manifest, which serves as the shipping document.

Explosives for Storage or Redistribution

Excess explosives to be retained by an individual or group may be shipped to Site 300 EDS, Building 818, for storage. Magazine space is limited and should be used for storage of "active" explosives only. Excess explosives no longer needed by an individual or group may be shipped to Site

300 for redistribution. Shipments from the Chemistry Area (Building 229) shall be sent to the Site 300 Chemistry Representative (Building 827); shipments from Building 345 shall be sent to the HE Technician Supervisor (M-3). Each recipient will then decide if the explosive can be used by others. The sender is responsible for providing a Chemistry Job Summary describing the best method of disposal if the explosive is a new material and if the decision is made to dispose of it as waste. Excess explosives from other areas will be handled on a case-by-case basis (contact the Site 300 EDS for information).

Explosives Waste

"Explosives waste" is defined as explosives-contaminated waste (for example, firing-tank shot debris or orange-can laboratory waste) or unneeded explosives material that is considered waste. For explosives-contaminated shot debris, explosive pieces larger than aspirin size must be removed and packaged separately; the remaining portions should be packaged in fiberboard boxes. Firing-tank shot debris originating from a complete detonation may be handled as nonexplosive waste. Liquid laboratory waste from the Chemistry Area is shipped in the original orange waste-collection can. Anytime explosives waste is to be shipped on public highways, HWM must be notified and a Hazardous Waste Shipping Manifest must be prepared. HWM is responsible for preparing the shipping manifest and coordinating the waste movement.

Preparation for Transfer

Packaging

Explosives for transfer are to be packaged in internal containers that provide protection from excessive movement, external stimuli, contamination, or spillage. Do not use screw-type container closures or other closures that apply excessive pinching or rubbing forces to explosives during closing and opening. Appropriate internal packaging of cardboard or plastic should be used for powders, liquids, or pastes. Glass containers are approved for only those liquids or pastes that are incompatible with plastic, and they must be packaged with sufficient dunnage capable of absorbing any liquid in case the container breaks. Approved external containers for transferring of explosives are:

- Metal container with lid (e.g., ammunition box, AN can).
- Site 300 high-explosive (HE) container (e.g., gray plastic tote box with lid).
- Original DOT shipping container.

If an explosive assembly is of such a configuration that one of these containers is not suitable, then the explosive may be transferred without a container, but extra precautions must be taken during loading and transportation to assure safe handling of the explosive. Explosive materials and electro-explosive devices (EEDs) are normally packaged separately when transferred. If explosive materials and EEDs are together in a device, the EEDs shall be kept shorted, and the device must be so labeled.

Labeling

Primary containers used for transferring explosives shall be tagged with an Explosives Identification Label (LL-4299) giving the name, weight, storage review date (if applicable), LLNL explosive classification, and storage group. Unlabeled or incorrectly labeled containers shall not be transported or shipped.

Documentation

The ID tag for controlled materials (LL-3076), which serves as the shipping document, is required when transferring explosives at the Livermore site. The tag must be properly completed in legible print. At Site 300 the ID tag for controlled materials is not required as long as the Explosives Identification Label is affixed to the transfer container.

Transporting Explosives

Driver Training

Only authorized personnel in approved vehicles are permitted to transport explosives. Driver selection and training for operation of LLNL vehicles on site and on public highways shall be in accordance with pertinent requirements of 49CFR 390–397. All drivers of explosives-carrying vehicles must have received proper training in the general safety precautions for explosives handling and specialized training for explosives transportation (HS-212). The procedure used to qualify explosives users is described in *Health and Safety Manual*, Section 24.03 In addition drivers must receive special training that emphasizes caution, road courtesy, and defensive driving. The course "Defensive Driving" (HS-560) satisfies this requirement. Registration procedures for these courses are described in Chapter 7 of the *Health and Safety Manual.*

Responsibilities

Movements of explosives on the Livermore site are handled by Materials Management Transportation or Site 300 Transportation. Hand-carrying of explosives by other personnel is permitted only when authorized by a Safety Procedure. All shipments of DOT Class A or B explosives for LLNL or between the Livermore site and Site 300 are transported by Site 300 Transportation. DOT Class C explosives may be carried on public highways by Site 300 or Livermore Transportation or Materials Management Transportation.

Before any properly equipped motor vehicle may be loaded with explosives (DOT Class A or B) in anticipation of movement over public highways, the vehicle must be inspected and approved by a qualified inspector for compliance with the checklist shown in either Appendix C (Form LL-6170) or D (Form CHP 148), as appropriate. After loading the checklist must be inspected and approved by the driver.

Before motor vehicles loaded with explosive materials leave the Livermore site or Site 300, drivers shall be informed of the nature of their cargo and methods of fighting fires involving the vehicle or its cargo. This is described in Appendix E, the Special Instructions for Motor Vehicle Drivers (form LL-6169). MMD (for shipments leaving the Livermore Site) or EDS (for shipments leaving Site 300) is responsible for informing the driver and properly completing this form, which is to be carried by the driver of each explosives shipment.

For on-site movements at Site 300, each operating group is responsible for transporting explosives under its direct control. When the control of an explosive is transferred from one operating group to another, the responsibility for its safe transportation also transfers to the new controlling group. An operating group should refuse to accept delivery, control, and responsibility for improperly packaged, unwanted, or unknown explosives.

Vehicle Controls

Explosives shall be transported only in vehicles that have been properly equipped, approved, maintained, and inspected. Any vehicle failing to meet these requirements shall not be permitted to transport explosives. The following equipment is required for all vehicles carrying explosives:

- Explosives placarding plainly visible from all directions. Placarding is not required for vehicles transporting DOT Class C explosives, unless the aggregate gross weight of Class C items exceeds 1000 pounds, then "Dangerous" placards are required.
- Two fire extinguishers with a minimum rating of 2A:10BC each—one mounted inside the cab and one outside the vehicle on the driver's side. Vehicles transporting DOT Class C explosives need only one extinguisher.
- Emergency four-way flasher.
- Backup light.
- Chock block.
- Tie-down mechanism for securing containers.
- Rear-view mirror on each side of the vehicle.
- Quick-disconnect switch on the battery.

- Covered cargo area or fire- and water-resistant tarpaulin.
- Cargo area with no sharp projections. A nonsparking lining is desirable when transporting explosives on site in transfer containers that are not DOT approved.

In addition to the general requirements stated above, all vehicles transporting explosives off site are required to have the following additional equipment:

- Sign for the rear of the vehicle indicating that it stops at railroad crossings (DOT Class A and B only).
- Portable emergency reflectors (3 each).
- Flashlight.
- Kit containing replacement sealed beam lights, light bulbs, and fuses (one spare for each kind and size on the vehicle).
- LLNL two-way radio.
- Fire retardant blanket if the vehicle has dual wheels.

Operational Controls

All drivers of explosives-carrying vehicles must observe the following controls:

- Obey the posted speed limit, but do not exceed 25 mph on site and 55 mph on public roads even if the posted speed limit is higher.
- Do not load a vehicle in excess of its rated weight limit.
- No smoking or flame is permitted within 50 ft of a vehicle carrying explosives.
- The driver of a vehicle containing explosives shall not leave the cab without first stopping the motor and setting the parking brake. If the vehicle is on a grade, one wheel must be chocked.
- Do not transport explosives if bad weather limits the driver's safe control of the vehicle.
- Personnel shall ride only in the cab of a vehicle transporting explosives. Do not exceed the normal passenger capacity of the vehicle.
- Do not operate motor vehicles within 25 ft of an open magazine.
- Personnel transporting explosives shall be familiar with the Emergency Section of this Supplement (Accident or Fire with a Vehicle Carrying Explosives).
- Explosives are not to be transported on site with any other hazardous material unless they are all part of a single assembly. The approval of the Materials Management Division is required to transport this type of unit off-site.

Vehicle Inspection and Maintenance

All LLNL vehicles used to transport explosives shall be equipped properly and inspected by the responsible operator once each day prior to use. If the inspection reveals any defects that will affect the safe operation of the vehicle, it will not be operated until repairs are made. During the inspection operators of vehicles must see that:

- Fire extinguishers are full and sealed.
- Electrical wiring is in good condition.
- Fuel tank and lines are not leaking.
- Brakes, lights, horn, steering, and other operating equipment such as a lift gate are functioning properly.
- Tires are in good condition and properly inflated (no recaps).
- Chassis and engine are reasonably clean and free of excess oil and grease.
- Exhaust system, including the tail pipe, is in good condition.
- Windows and mirrors are clean and rear-view mirror alignment is good.

All drivers assigned vehicles for transporting explosives shall be responsible for obtaining an inspection by **Fleet Management (Garage)** every **three months** to ensure the vehicle is properly equipped and in proper condition. **Fleet Management** shall correct vehicle defects as required and perform routine service and inspection. The completed inspection report (Appendix F, form RL-2653) shall be mailed to the supervisor concerned with a copy to Hazards Control Explosives Safety (L-871).

Fleet Management shall perform a thorough steam cleaning of the engine, chassis, and underbody of all vehicles every **three** months (or more often as needed). If the cargo compartment requires cleaning, contact the Site 300 Process Area Supervisor for explosives decontamination work.

When a vehicle is removed from service as an explosives transportation vehicle, it must be decontaminated. Hazards Control Explosives Safety will then make an inspection to verify that the vehicle is free of explosives.

Material Compatibility

All explosives and other hazardous materials being transported in the same vehicle must be compatible. The Loading Chart found in 49CFR 177.848 shall be followed any time explosives are to be transported.

Approved Routes

While transporting explosives on site, travel to the destination should be by the most direct, least congested route. Transportation of explosives on public highways is under the surveillance of the California Highway Patrol. Approved routes, stopping places, and rules of the road are outlined in the Department of the California Highway Patrol publication *HPH 84.3, Explosives Routes and Stopping Places*.

Currently, two approved explosives routes exist between the Livermore site and Site 300. The first route is by way of Corral Hollow Road (west), Tesla Road, and Greenville Road. The other route is by way of Corral Hollow Road (east), Interstate 580, and Greenville Road. The first route has the advantage of presenting less exposure to the general public and should be used preferentially. There are no approved stopping places on either route.

Vehicle Breakdowns

Observe the following guidelines when a vehicle breakdown occurs while transporting explosives:

- Park the vehicle off the roadway as far as practical.
- Use red emergency reflectors as warning devices for passing vehicles.
- *DO NOT* leave the vehicle unattended.
- Use LLNL two-way radio to report trouble when possible. If necessary and the vehicle is off site, ask a passerby or the police to assist in reporting trouble.
- Before repairs are performed, contact Hazards Control to determine if the explosives should be removed from the vehicle.
- If explosives are removed from the vehicle, place them in a protected area within view and control or have the explosives transported to their destination by another LLNL explosives vehicle.

Emergencies

In the event of a fire or accident involving a vehicle carrying explosives off-site, follow the Special Instructions for Motor Vehicle Drivers (see Appendix E).

In the event of a fire or accident involving a vehicle carrying explosives on site, notify the emergency response personnel as soon as possible via radio or telephone, Ext. 3-5333 (Site 300) or Ext. 2-7333 (Livermore), and adhere to the following procedure as appropriate:

Vehicle Accident with Spilled Explosives and No Fire:

- Shut off ignition of involved vehicle.
- *DO NOT* smoke or use highway flares within 50 ft of vehicle or explosives.
- Set up road warning devices using signs or available personnel.
- Give aid and assistance to any injured people.
- Prevent people and vehicles from moving through spilled explosives. Close a lane or the entire roadway as required.

- Avoid rough handling of explosives containers.
- Gather any spilled explosives, place them in an isolated spot away from people and vehicles, and identify the explosives by any available method.
- In the event of a delay in obtaining another vehicle, the person responsible for the explosives may do the following if the damaged vehicle creates a hazardous situation:
  —Remove the explosives from the damaged truck and carry them to an isolated, safe location.
  —Block off the area around the explosives and identify the explosives with signs.
  —Have the damaged vehicle moved.

Vehicle Fire or Accident with Fire:

- Take prompt action to extinguish electrical fires in motor compartment if it can be done with minimum risk.
- If the fire is outside the motor compartment, involves fuel or rear tires, or if the fire is threatening the explosives cargo, evacuate all personnel to the appropriate distance specified in Table 1 of *Health and Safety Manual* Supplement 24.30. The normal standoff distances are described in the "Special Instruction Form for Motor Vehicle Drivers," Appendix E of this Supplement. If the the table is not available, evacuate to a distance of 2000 ft. *DO NOT ATTEMPT TO FIGHT THIS FIRE.*
- Give all available information concerning the weight and type of explosives involved to responding emergency response personnel.

Accident with No Fire and No Spill:

- Shut off ignition.
- *DO NOT* smoke or use highway flares within 50 ft of explosives-carrying vehicle.
- If any containers are broken or leaking, treat as described above for a vehicle accident with spilled explosives.

Appendix A
Procedural Guide for Shipping an Explosive

A. Introduction

This guide describes the steps that need to be taken before an explosive (i.e., material or device) may be shipped from LLNL. Explosives can be categorized as Forbidden, Acceptable, or New. Forbidden explosives may not be shipped (Section B). All other explosives may be shipped as Acceptable explosives (Section C) or as New explosives (Section D). An explosive may need to be subjected to laboratory-scale tests as described in Appendix B before a final decision can be made as to how it is to be shipped.

B. Forbidden Explosives

Explosives listed below are generally forbidden for shipment on a public highway. Contact Hazards Control Explosives Safety for additional information.

- Explosive compounds, mixtures, or devices that ignite spontaneously or undergo marked decomposition when subjected to a temperature of 167°F (75°C) for 48 consecutive hours.
- Explosive mixtures or devices containing an ammonium salt and a chlorate.
- Explosive mixtures or devices containing an acidic metal salt and a chlorate.
- Initiating explosives when dry.
- Nitroglycerine, diethylene glycol dinitrate, or other liquid explosives, except as authorized by DOT.
- Leaking or damaged packages of explosives.

C. Shipping Acceptable Explosives by Commercial or DOE Vehicles

Acceptable explosives either: (1) have already been approved by DOE/DOT for shipment, or (2) require approval only by analogy because they are similar in composition and hazard characteristics to an already approved Acceptable explosive.

1. Acceptable Explosives Already Approved by DOE/DOT

If an explosive has already been classed and approved by DOE/DOT for shipment by commercial carrier, then it may be shipped by commercial or DOE vehicle using the same classification and shipping description without additional tests and authorizations. The shipping procedure is described on page 2 of this Supplement. Contact the Materials Management Division (MMD) or the Explosives Distribution Section (EDS), Site 300, for assistance.

2. Acceptable Explosives Requiring Approval by Analogy

When an explosive is similar in composition and hazard characteristics to an already approved explosive, then the not-yet approved explosive may also be approved. The shipper prepares a written request for approval for shipment by analogy. The memo is addressed to MMD with a request to forward it to the DOE-SAN for approval. Copies of the memo are to be sent to Hazards Control Explosive Safety (L-871) and the Site 300 Explosives Distribution Section (L-818).

The memo must describe the desired mode of transportation, must state that the explosive is not a new explosive as its composition is similar and its hazard characteristics are less than or equal to the explosive that has already been classed and approved, and must conclude with a statement that the explosive under consideration is at least as safe as the previously approved explosive. Include results from tests conducted for both explosives and any other information that would be helpful in reaching a final decision.

A member of the Hazards Control Explosives Safety Group will review the request memo from the shipper and, if he or she agrees, will submit a memo to MMD that covers the following:

- The proposed classification, marking, labeling, and mode of transportation.
- The results of any testing with a statement that the material does not significantly exceed the previously classed explosive's sensitivity to heat, shock, and energy output and thus is at least as safe as the previously approved explosive material or device.
- A description of the DOT-specified packaging or approved exemption.
- That the total quantity of explosive in a device is not greater than that contained in the previously classed explosive device and for each item is within 3 grams of the explosives device originally classed.
- That there is no significant change in the configuration in terms of directional energy output or shaping effect, and length-to-diameter ratio is equal to or lower than the previously classed item (for a device only).
- That there is no reduction in the containment characteristics of the outer package, including the container, its latches, banding, and sharp edges (for DOT Class C only).
- That there is no significant decrease in the integrity of the packing material, baffles or separations, orientation, or separation distance, if more than one item is contained in a package (for DOT Class C only).

The memo from Explosives Safety and the test results are forwarded to the DOE-SAN by MMD in the manner described in the latest version of the controlling DOE-SAN directive. If all parties are in concurrence, both DOE and DOT will issue approval memos. The shipping procedure is described on page 2 of this Supplement. Contact MMD or the Site 300 EDS for assistance.

D. Shipping New Explosives

By definition New explosives are not similar to any already-approved explosive. They may be shipped only: (1) by DOE vehicle to a testing facility, or (2) by commercial carrier or DOE vehicle to a laboratory for examination prior to classification and approval. Test criteria for classifying a new explosive material or device that cannot be classified by analogy are contained in the DOD Explosives Hazard Classification Procedures, TB 700-2.

1. By DOE Vehicle

A New explosive may be shipped from where it was produced to an explosives testing facility (e.g., between Livermore site and Site 300), provided it is:

- Not a Forbidden explosive.
- Accompanied by a second person who is qualified by training and experience to handle the explosive.
- Appropriately described on the shipping papers as high explosive or high-explosive liquid and packaged, marked, and labeled as required by DOT (for an explosive compound or mixture).
- Assigned a tentative description and class by the manufacturer and packaged, marked, labeled, and described on the shipping papers as required by DOT (for an explosive device).

The shipping procedure is described on page 2 of this Supplement. Contact MMD or the Site 300 EDS for assistance.

2. By Commercial Carrier/DOE Vehicle to a Laboratory for Examination

Before a new explosive can be shipped to a laboratory for examination, the following conditions must be fulfilled:

- DOE must assign the new explosive a tentative shipping description and class in writing.
- The sample is to consist of no more than five pounds of new explosive.
- The sample must be packaged as required by DOT unless otherwise specified in writing by DOE.
- The package must be labeled as required by DOT. The words "SAMPLE FOR LABORATORY EXAMINATION," the net weigh, and the tentative shipping description are to be marked on the package.

A request for a tentative shipping description and class is made to MMD in the same manner as described in Section C, above. Hazards Control Explosives Safety will provide an evaluation of the explosive and recommend a tentative shipping class and description before a request is forwarded to DOE-SAN for approval.

Appendix B
Lab-Scale Sensitivity and Stability Tests

Introduction

The lab-scale screening tests described in this appendix are available at LLNL. They are intended to develop data on the sensitivity and stability of an explosive. By evaluating the test results, the hazard characteristics of an explosive for shipping purposes can reasonably be determined. These lab-scale tests are valid only for explosive materials, not for explosive devices.

These tests cannot be substituted for the full-scale tests described in DOD Explosives Hazard Classification Procedure, TB 700-2 (9/82), that are prescribed by the DOT regulations for the full and final classification of a new explosive. Table B-1 lists general comparisons between these two types of tests.

Table B-1. General comparisons of TB 700-2 tests and LLNL lab tests.

	TB 700-2 Tests	LLNL Lab Tests
Impact Sensitivity	Bureau of Explosives impact test. 3.6-kg weight on 10-mg sample. Ten trials each at 9.5- and 24.5-cm drop height.	Drop-hammer impact test. 2.5-kg weight on 35-mg sample. Type-12 tooling (sandpaper). 50%-point determination.
Thermal Stability	75°C/48 hr. 5-cm cube.	120°C/22 hr. 0.25 g. Gas-evolution (CRT) test. DTA at 10°C/min and 2°C/min for 20 mg. Plot of endothermic and exothermic reactions.
Detonation	No. 8 blasting cap on a 5-cm cube (five tests).	None
Shock Sensitivity	NOL card gap 3.8-cm diameter ×13.9-cm long confined in steel tube. Three test minimum, 12 test maximum to obtain 50%-point for gap (shock attenuation).	Small-scale gap test. 12.7-mm diameter × 38.1-mm long confined in lucite. Minimum tests to determine gap range.
Ignition and Unconfined Burning	5-cm cube on kerosene-soaked sawdust. Burning time or explosion recorded. Two tests on single cube and one test on four cubes placed end to end.	None

Test Data Evaluation

The data obtained from a lab-scale test is evaluated to determine if an explosive has sensitivity or stability characteristics that make the material DOT Forbidden. In addition, these tests can be used with other information to differentiate between a DOT Class A or Class B explosive.

Forbidden Explosives

An explosive may be a Forbidden explosive because of its composition or because it can undergo marked decomposition when subjected to 75°C for 48 consecutive hours. The LLNL chemical reactivity test (CRT) is run at 120° C for 22 consecutive hours, and gas-evolution measurements are made and analyzed. Materials that undergo marked decomposition at 75° C can readily be identified by CRT results. Differential thermal analysis (DTA) and the one-dimensional time-to-explosion (ODTX) test can also help in characterizing thermal stability.

An explosive compound or mixture with an impact sensitivity of less than 10-cm drop height (Bureau of Mines apparatus) is an 'initiating explosive.' These explosives must be desensitized before shipment, as described in 49CFR 173.53. Included in this group is PETN, which is less sensitive than most other explosives in the group. Any explosive more sensitive to impact than PETN on the LLNL drop-hammer test is to be considered an initiating explosive.

DOT Class A or Class B

This testing and evaluation is required only when a tentative description and class (as a DOT Class B) needs to be assigned to an explosive sample being sent to a laboratory for examination.

If any *one* of these tests gives the following results, the sample is listed as a tentative DOT Class A explosive:

- Impact-sensitivity test produces an explosion with drop-heights of 10 cm or more, but not more than 25 cm.
- Thermal-stability test results in an explosion, burning, or marked decomposition, but at a temperature greater than 75° C.
- Sensitivity-to-shock-initiation test indicates a sensitivity of 70 or more cards.

If *all* of the following tests give the results as indicated, the sample is listed as a tentative DOT Class B explosive:

- Impact-sensitivity test does not result in an explosion at 25 cm or less.
- Thermal-stability test does not result in an explosion, burning, or marked decomposition.
- Sensitivity-to-shock-initiation test indicates a sensitivity of less than 70 cards, or no reaction at zero cards.

A major test to differentiate between Class A and Class B in the full-scale examination program (see Table B-1) is the shock-sensitivity threshold as determined by the NOL card-gap test. Since no direct correlation exists between the LLNL lab-scale gap test and the NOL test, any recommendation to DOE for a tentative Class B designation should include a comparison with similar materials previously classed.

Impact-Sensitivity Tests

Determine the impact sensitivity of an explosive or other energetic material by impacting it with a 2.5-kg weight falling freely from a predetermined height. Place the 35-mg sample pellet on a piece of sandpaper (Type-12 tooling) or on a roughened steel surface (Type-12B tooling). Summarize the test results as the height (cm) at which the probability of explosion is 50% (calculated by using the standard Bruceton method). An "explosion" is determined by an arbitrarily set level of sound produced by the explosive upon impact. Measure the sound with a transducer set to give a zero reading when the hammer, falling from its highest point (177 cm), strikes the anvil. Composition B is used as a standard, producing a sound-level set at 100 when exploded by the hammer dropped from its highest point. Always report the drop-hammer numbers relative to standard explosives, such as HMX, RDX, TNT, and/or PETN. Table B-2 shows typical data for these tests.

Thermal Stability Tests

Determine the thermal stability of an explosive by making two separate measurements—a standard differential thermal analysis (DTA) and a chemical-reactivity test (CRT). In the usual DTA set up two identical containers, one containing the sample and the other containing a standard reference substance, in identical thermal geometries. Arrange the temperature sensors to give both the temperature of each container and the difference in temperature between the containers. The data are

Table B-2. Typical data for impact-sensitivity tests.

PBXs	Type-12 Tooling Drop Height (cm)
LX-04	41
LX-07	38
LX-09	32
LX-10	35
LX-11	59
LX-14	53
LX-17	>177
PBX-9404	34
Castable	
Comp. B	45
TNT	80
Powders	
HMX	33
RDX	28
PETN	11 (initiating explosive)

displayed as a DTA thermogram plotting the temperature difference against the temperature of the sample. If the sample has no rapidly changing thermal behavior, this plot will be almost a straight line. Excursions below and above the baseline are due to endothermic or exothermic changes. The DTA analysis permits the interpretation of phase changes, decomposition, melting points and, from these, kinetic information and thermal stability.

Sample sizes are on the order of 20 mg. Since the temperature of a thermal event is determined to some extent by the rate of heating, various heating rates are used. The standard rates are 10°C/min and 2°C/min.

In the chemical-reactivity test, heat a ~0.25 g sample under a helium blanket at 120°C for 22 hours. Use a two-stage chromatography unit to measure the individual volumes of N_2, NO, CO, N_2O, and CO_2. This test is used principally to determine the reactivity of explosives with other materials. While the standard temperature is 120°C, explosives are frequently investigated at other temperatures and for other periods of time. Table B-3 lists typical data for these tests.

Sensitivity to Shock Initiation Tests

The shock-initiation sensitivity of an explosive is measured by a gap test. Subject the new explosive to a shock wave generated from a standard donor material and attenuated through a thickness of inert spacer materials. Express the data in terms of the number of cards or the thickness of spacer material that will attenuate the shock enough to decrease the probability of detonation to 50%. In general the larger the gap, the more shock-sensitive is the explosive. The actual numbers, however, depend on test size and geometry as well as on the particular lot, method of preparation, and density of the explosive, and are therefore only indicators of relative shock sensitivity. We use the LANL-generated small-scale gap test. In this test, the explosive samples are pellets 12.7 mm in diameter and 38.1 mm long. The gap spacers are brass shims in 0.254-mm increments. The donors are modified SE-1 detonators with PBX-9407 pellets 7.62 mm in diameter and 5.26 mm long. Detonation of the samples is ascertained by a dent produced in a 152-mm-square, 102-mm-thick, steel witness plate. The values are expressed in millimeters or in mils of brass. Table B-4 shows typical data for these tests.

Table B-3. Typical data for DTA and CRT tests.

DTA — Graphic plot showing endothermic and exothermic reactions. Temperatures of onset of first exotherm can be identified.

CRT — Gas evolved (cm^3) from 0.25 g after 22 hr / 120° C.

PBXs	Gas evolved (cm^3)
LX-04	0.01–0.04
LX-07	0.01–0.04
LX-09	0.03–0.07
LX-10	0.02–0.06
LX-11	0.01–0.04
LX-14	0.02
LX-17	0.02
PBX-9404	0.36–0.40
Castable	
Comp B	0.05
TNT	0.0–0.01
Powders	
HMX	0.01
RDX	0.02
PETN	0.10–0.14

Table B-4. Typical data for shock-sensitivity test. Gap thickness for cast or pressed pellets:

PBXs	Gap thickness (mm)
LX-04	1.0–1.5
LX-07	1.8– 2.3
LX-09	1.9–2.7
LX-10	2.0–2.5
LX-11	1.1–1.7
LX-14	1.5–2.0
LX-17	1.3–2.3
PBX-9404	2.2–2.7
Castable	
Comp B	1.1–1.4
TNT	0.2–0.4
Pressed Powder	
RDX	4.8–5.6
PETN	4.8–5.6 (both shipped wet)
TATB	0.05–0.41 (shipped dry)